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Cataclysme subtilisparsata Wehrli, 1932 (Lepidoptera, Geometridae, Larentiinae) recognized as bona species – an integrative approach

Dirk Stadie[1], Axel Hausmann[2], Hossein Rajaei Sh.[3]

1 *Bahnhofstraße 13, 06295 Lutherstadt Eisleben, Germany; Dirk.Stadie@t-online.de*
2 *SNSB - Bavarian State Collection of Zoology Munich, Münchhausenstraße 21, 81247 München, Germany; Axel.Hausmann@zsm.mwn.de*
3 *Biocentre Grindel and Zoological Museum, University of Hamburg, Martin-Luther-King-Platz 3, 20146 Hamburg; Stuttgart State Museum of Natural History, Rosenstein 1, 70191 Stuttgart, Germany; hossein.rajaei.shoorcheh@uni-hamburg.de*

http://zoobank.org/E9C4F2AA-0CA7-4147-B8E2-B748A38F2154

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Abstract. Based on morphological and molecular analyses of "*Cataclysme riguata* Hb. var. *subtilisparsata* Wehrli, 1932" and *C. riguata* (Hübner, 1813) the former is raised to species rank. *C. subtilisparsata* is re-described here and compared with *C. riguata*. Molecular data derived from DNA barcoding are discussed. We illustrate male and female genitalia of both species and present data on life history and morphology of the early stages of *C. subtilisparsata*.

Introduction

Cataclysme Hübner, [1825] is a small West-Palaearctic genus of moths belonging to the tribe *Cataclysmini* Herbulot, 1961 (Larentiinae, Geometridae). Viidalepp (2011) and Hausmann and Viidalepp (2012) listed the tribal diagnostic characters. In both checklists of Scoble (1999) and Scoble and Hausmann (2007) seven species are listed for this genus. Recently Viidalepp (2009) and Choi and Stüning (2011) revised the Eastern Palaearctic genus *Paraplaneta* Warren, 1895, recognizing eight species for *Paraplaneta* and leaving five species in the genus *Cataclysme*. All members of *Cataclysme* are of medium size, their coloration varying from light brownish to dark grey. On the wing upper side all transverse lines are well developed, sinuate or dentate, distinct, and whitish. The coloration of the head, frons and vertex correspond rather well to that of the wings. The palpi are short, reduced in size, the proboscis is well developed and chaetosemata are present as two elongate patches. The abdomen and anal tuft are concolorous with wings. Male antennae are broadly flattened laterally, with very short ciliae, which are bipectinate in the closely related genus *Paraplaneta*. The forewing R5 is stalked with M1, and the areole is present. In male genitalia the uncus is flat, bifid with projections distally rounded and basally fused (Viidalepp 2009). The male genitalia have a "pseudojuxta" (see streak in Fig. 7a), an autapomorphy of *Cataclysme* and *Paraplaneta* within the tribe Cataclysmini (Choi and Stüning 2011). The phallus is long, with termino-lateral spinulose crests

('dorsal-external carina' in Viidalepp 2011) and forked vesica with lines of cornuti (the latter are not present in *Paraplaneta*). The female genitalia (except for corpus bursae) are strongly sclerotized. The ductus bursae is furrowed, the ostium cleft and fused to sternite A7 (Viidalepp 2011). The species are bivoltine or facultative bivoltine and inhabit Mediterranean macchia such as all kinds of steppe biotopes from forest to open xero-montane steppes. So far as is known the larvae are oligophagous feeding on species of *Galium* and *Asperula* (Rubiaceae).

Cataclysme subtilisparsata Wehrli, 1932 was described as a variation of *Cataclysme riguata* (Hübner 1813) based on two specimens (1 ♂, 1 ♀; collected by Pfeiffer near Maraş in June 1929). Prout (1938) regarded the first as a subspecies of the latter, while Scoble (1999) did not mention that taxon at all. The status of this taxon remained unclear until now, due to the lack of sufficient material. Specimens recently collected in south-east Turkey, however, are allowing an integrative taxonomic revision of this taxon. Breeding experiments were undertaken to obtain more information about larval morphology and bionomic data. Results of morphological (genitalia) and DNA-barcode analyses show *C. subtilisparsata* to be a distinct species (the sixth of the genus) and not a form or subspecies of *C. riguata*.

Materials and methods

Morphological studies

Specimens were photographed before performing a standard method of dissection (Robinson 1976). Genitalia slides were photographed using Zeiss digital stereomicroscope (ZEISS-SteREO: Discovery.V20). Specimens were identified based on comparison with the syntype and the original description (Wehrli 1932).

More than 300 specimens of *Cataclysme riguata* were examined for comparison from following regions: Turkey (west, north, east), Iran (north, west, central), Caucasus (Georgia, Russia, Armenia), Europe (e.g. Germany, Austria, Hungary, France, Spain, Italy, Slovenia, Croatia, Macedonia, Greece, Bulgaria, Ukraine). Furthermore specimens of the following species were used for morphological examination and DNA barcoding (see Appendix): *Cataclysme uniformata* (Bellier, 1862); *C. dissimilata* (Rambur, 1833); *C. festivata* Staudinger, 1892; *Paraplaneta sternecki* (Prout, 1938).

Specimens from the following collections have been examined:

ZFMK Zoological Research Museum Alexander Koenig, Bonn
ZSM Bavarian State Collection of Zoology, Munich
PCDS Private collection Dirk Stadie, Lutherstadt Eisleben

DNA amplification and sequencing

PCR amplification and sequencing of 658 bp of COI mtDNA of the three freshly collected specimens of *C. subtilisparsata* was successful using standard protocols (Ivanova et al. 2006) at the Canadian Centre for DNA Barcoding (CCDB; Guelph), in the framework of the Lepidoptera Campaign of the international Barcode of Life program iBOL (see: www.lepbarcoding.org).

Data analysis

Sequences were aligned using BOLD platform (www.boldsystems.org). For construction of the neighbour-joining tree (using K2P model: Kimura 1980) and for calculation of the genetic distances we used MEGA5 (Tamura et al. 2011). For analysis the DNA barcodes of 17 individuals (of five *Cataclysme* and one *Paraplaneta* species) with fragment length >500bp were used. All sequences can be accessed in public projects on the barcode of Life Data Systems (BOLD; data-set DS-Cataclys, www.boldsystems.org; cf. Ratnasingham and Hebert 2007), such as in GenBank (for list of analyzed specimens and their GenBank accession numbers see Appendix).

Results and discussion

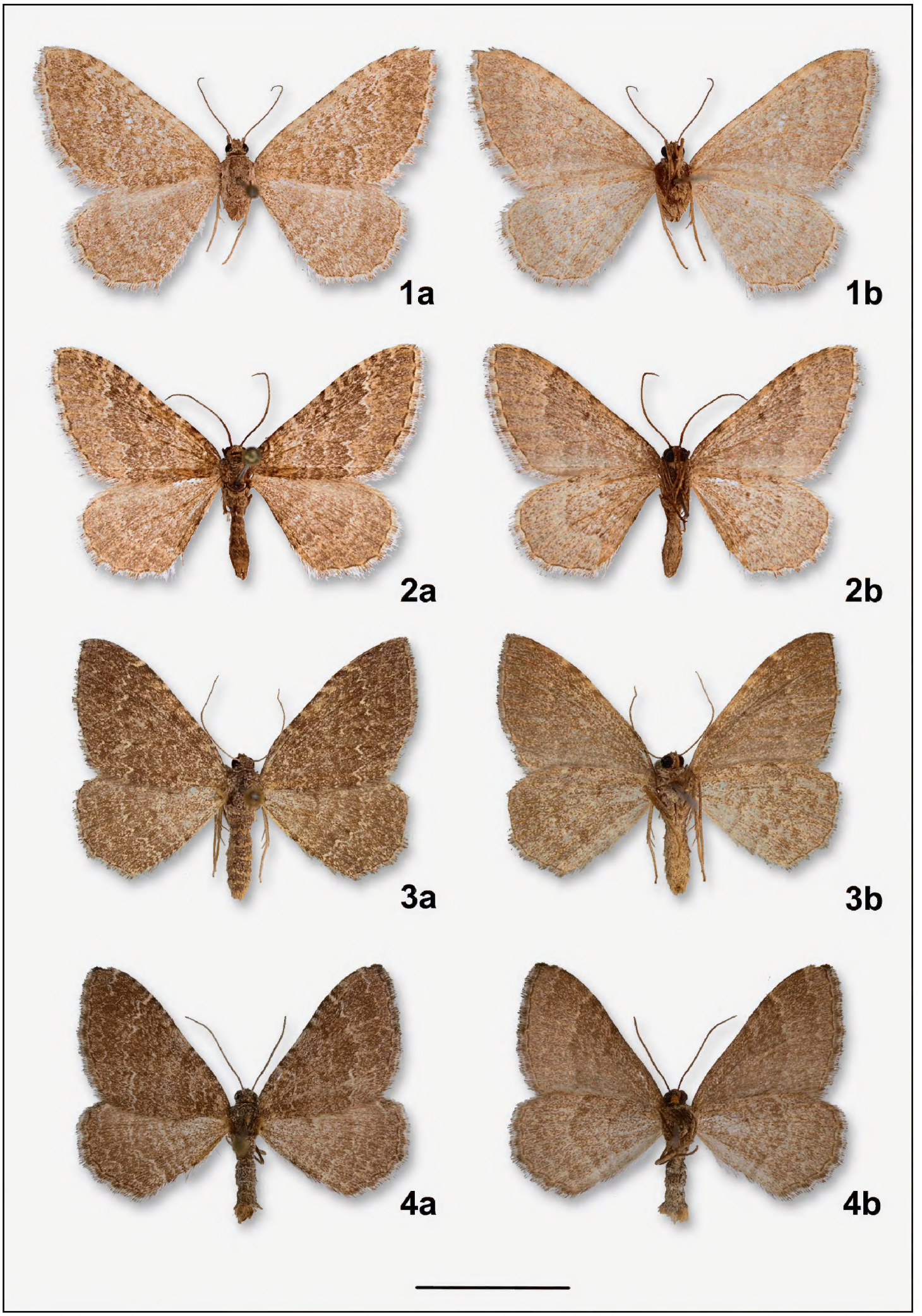
Cataclysme subtilisparsata Wehrli, 1932, bona sp.

Figs 1, 2, 5, 6, 10 and 11

Cataclysme riguata Hb. var. *subtilisparsata* Wehrli, 1932: Mitt. Münchn. Ent. Ges. 20: 7. Locus typicus: southern Turkey, Achyr Dagh near Maras: Bertiz Jaila. Syntypes 1 ♂, 1 ♀ (female traced in ZFMK; male not traced). The original description of *subtilisparsata* does not include any indication for an infrasubspecific understanding but compares features in correlation to geographic distribution areas. Although in Wehrli's paper several other taxa are introduced as "ssp." this fact alone cannot be interpreted generally and "without doubt" (cf. §45.6.1 Code ICZN) as an infrasubspecific meaning of "var." in Wehrli (1932). Therefore the name is available according to §45.6.1 Code ICZN.

Material examined. Lectotype (hereby designated in order to stabilize nomenclature) ♀, "Syr. sept. [Turkey], Marasch, Achyr Dagh sept. Bertiz Jaila, 1800m, 09.-13.vi. [19]29, E. Pfeiffer leg.", "*Cataclysme riguata* Hb. var. *subtilisparsata* Wrli.", "Type", "Prep. Nr. G 81, ♀, G. Ebert", "BC ZFMK Lep 00781"; 1 ♀, S-Ost [S-East] Turkey, Hakkari Uludere, Tanin Tanin, 2200 m, 05.vi.1985, leg. P. Kuhna; 1 ♀, Ost [East] Turkey, Van, 2600 m, Güzeldere Paß, 06.vii.1979, leg. P.Kuhna, g. prep. 1491/2011 H. Rajaei; 1 ♂, same data, 18.vi.1985; in ZFMK. 5 ♂, 5 ♀, Turkey centr. Provinz Adiyaman, Nemrut Dag, 38°02'07" N / 38°45'48" E, 1700-2000 m ü.NN, 23.-25.v.2009, LF, leg. Fiebig & Rothe, g. preps: ♂ 1805, ♀ 1806/2012 H. Rajaei; in coll. Stadie. 1 ♂, "Syria s., [Turkey], Taurus, Marasch, Einh.Slg. [local collectors] leg., 20.vi.34: in ZSM. 1 ♂, same data, viii.29; 2 ♂, same data, x.29, one with g. prep. ZSM G 8945; 1 ♂, O-Turkey, Hakkari, östl. Bagisli, 1600 m, 09.vii.1979, leg. Gross, in coll. EMEM/ZSM. 1 ♀, [northern] Iran, Pr. Mazandaran, Al Borz Mts. [Resteh-Ye-Elborz], 2998 m, Mazandaran Pass, 36.231° N / 51.438° E, leg. and coll. G. Petrany, DNA Barcode BC PG Lep 0100.

Redescription. Wingspan 25–29 mm, forewing length 13.2–15.0 mm; n=11. Apex pointed. Termen slightly rounded. Ground colour of forewing light ochre-brown to light grey-brown; basal and medial area darkened in half of all individuals, the others rather uniform; transverse lines well developed, distinct and dentate; postmedial line bordered distally with white scales; subterminal line narrow, whitish, more or less complete; terminal line fine dark brown, streak-like, interrupted at the veins; costa often suffused with whitish scales. Cell spots round, always present but often weak and hardly visible. Fringes slightly lighter than ground colour, chequered. Hindwing colour slightly lighter than forewing. Transverse lines usually indistinct except the postmedial and terminal lines. Cell



Figures 1–4. Wing pattern. **1** and **2**, *Cataclysme subtilisparsata*: **1.** Lectotype, ♀, Achyr Dagh (Marasch, Turkey); **2.** ♂ from Nemrut Dag (Adiyaman prov. Turkey). **3** and **4**, *Cataclysme riguata*: **3.** ♀ from N Aksar (NE Turkey); **4.** ♂ from West Ügrüp (Turkey); a. upperside; b. underside. Scale bar: 1 cm.

spots usually absent. If present then very weak, developed as an elongate streak. Underside of both wings lighter than upper side, suffused with light ochre-brown scales. Transverse lines absent or strongly reduced except the postmedial and terminal lines. Cell spots on both wings weak, but always present. Head and frons unicolorously ochre-brown. Palpi reduced in size. Antennae of male slightly dentate in lateral view, those of female filiform. Tibia of forelegs without spurs, of mid-legs with one pair, of hindlegs with two pairs of spurs. Chaetosemata present.

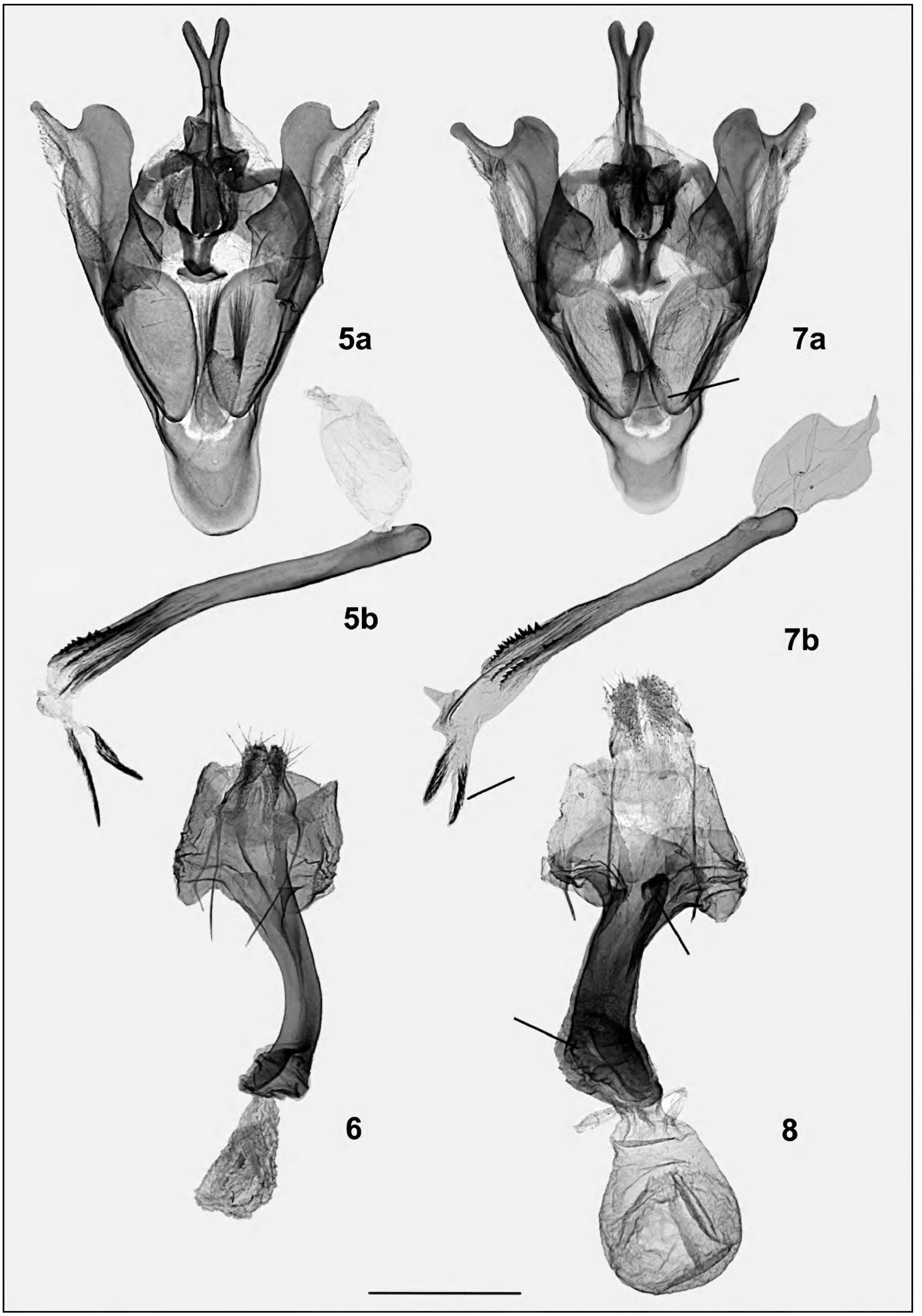
Male genitalia. Uncus flat, bifid, projections distally rounded. Valva broadly sclerotized at costa, with a rounded lobe and a deep, sub-apical incision. Apical projection thin, with small rounded tip. Juxta narrow and largely reduced, situated between the oval basal parts of the valvae and behind the pseudojuxta (only partly visible in Figs 5a, 7a), saccus well developed, broad. Phallus straight, long and slender with termino-lateral spinulose crests; vesica biforked with numerous cornuti (Figs 5a, b).

Female genitalia. Ductus bursae furrowed, slightly curved, near ostium remarkably widened, more sclerotized. Corpus bursae membranous (Fig. 6).

Diagnosis. *C. subtilisparsata* differs from the closely related *C. riguata* by its slightly larger size. Wingspan in the latter 20–25 mm (n>100) in the former 23–27 mm (n=16), in one specimen from Hakkari, however, only 21 mm. The ground colour is notably lighter, on average. Specimens with darkened basal and medium field never occur in *C. riguata*. Despite a wide range of variation the transverse lines, especially basal and antemedial lines, are often more zigzagging and thus more reminiscent of *C. uniformata* (Bellier 1862) than of *C. riguata*. Furthermore, the forewing cell spots are usually absent in the latter. In male genitalia, pseudojuxta of *C. riguata* (Fig. 7a) round, in *C. subtilisparsata* elongate sub-rectangular (Fig. 5a). In female genitalia, ductus bursae of *C. riguata* (Fig. 8) larger, more robust and more strongly sclerotised than in *C. subtilisparsata* (Fig. 6)

DNA barcoding. Genetic similarity and interspecific distances are shown in the neighbour-joining tree (Fig. 9). Exact distance values are listed in Table 1. Based on these data *Calaclysme subtilisparsata* is more than 7% divergent from all other examined *Calaclysme* and *Paraplaneta* species, confirming our hypothesis of species rank for *C. subtilisparsata*. However, sequencing of more specimens from northern Iran and all regions of Turkey is highly recommended. Furthermore, the identity of the taxon *festivata* needs to be investigated (cf. Fig. 9) and its lectotype designated. We consider here the populations from Kyrgyzstan and Uzbekistan as belonging to this taxon. The interpretation of Scoble (1999) (mentioning 'Amur' as locus typicus) is erroneous; Staudinger (1892) clearly states that "the Central Asian populations from Alai, Alexander Mountains, Osch, Usgent, Namangan and Prov. Samarkand" should bear this name. Preliminary data furthermore suggest that there is another taxon forming a separate genetic cluster, so far recorded from Georgia, eastern Turkey and Altai mountains. We do not exclude the possibility that this cluster refers to "*Cataclysme riguata elbursica* Wagner, 1937". *Cataclysme shirniensis* Ebert, 1965 (described from N. Afghanistan) is not included in the present study due to the lack of material.

Geographic distribution. So far *Cataclysme subtilisparsata* is known only from the high mountain chains of south-east Turkey from Ceyhan Valley in the west to the mountain ridge south of Van in the east and Mazandaran in north Iran (see Fig 9).



Figures 5–8. Male and female genitalia. **5** and **6**, *Cataclysme subtilisparsata*: **5.** male (gen prep. 1805/2012 H.R.); **6.** Lectotype (gen prep. G 81); **7** and **8**, *Cataclysme riguata*: **7.** male (gen prep. 1807/2012 H.R.), **8.** female (gen prep. 1492/2011 H.R.); a. male genitalia aparat; b. phallus. Abbreviations. pj, pseudojuxta; tl.c, termino-lateral crests; v, vesica. Scale bar: 1 mm.

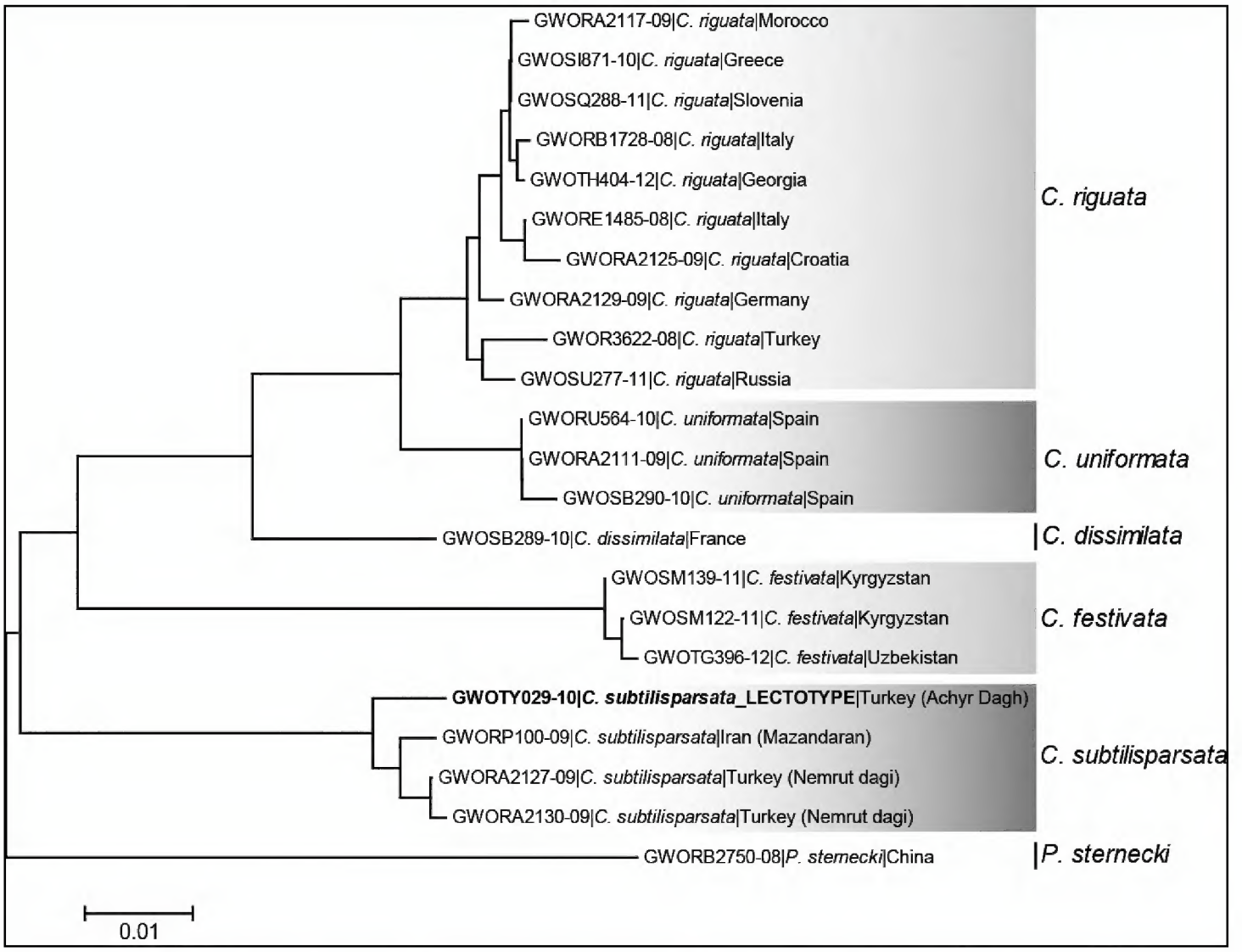


Figure 9. Un-rooted neighbour-joining tree based on individuals belonging to six species of the genera *Calaclysme* and *Paraplaneta* (calculated using the Kimura 2-parameter model with MEGA 5 (Tamura et al. 2011)).

Table 1. Interspecific distances between six species of the genera *Cataclysme* and *Paraplaneta* (in %) (based on COI 5' mt-DNA gene fragments, calculated using the Kimura 2-parameter model with MEGA 6 (Tamura et al. 2011)). The distances between *C. subtilisparsata* and other taxa have shown in bold.

	1	2	3	4	5
1. *C. uniformata*					
2. *C. festivata*	9.3				
3. *C. subtilisparsata*	**8.7**	**9.8**			
4. *C. riguata*	2.4	9.1	**8.6**		
5. *P. sternecki*	10.5	11.3	**9.5**	10.7	
6. *C. dissimilata*	4.2	8.6	**7.2**	4.2	9.7

Bionomics. Similar to other *Cataclysme* species, *C. subtilisparsata* is a bivoltine species. The flight period of the first generation lasts from mid-May to the first third of June. The second brood occurs in July (result of *in-vitro* breeding experiments by first author and *in-vivo* by Ralf Fiebig in Nemrut-mountain, pers. comm.). The species inhabits steep, more humid east- and north-facing escarpments and outcrops from 1500–2100 m above sea level. The slopes are mainly covered with stands of thorny cushion plants dominated by xero-montane *Acantholimon* (Plumbaginaceae) and *Astragalus* (Fabaceae) mixed with

Figures 10, 11. *Cataclysme subtilisparsata* in Turkey, Dogu Anadolu, Province Malatya, north of Nemrut Dag. **10.** Imago (female), **11.** larva.

herbaceous vegetation. The host plant is probably a low growing, white-flowering *Asperula* sp. (Rubiaceae). In captivity the caterpillars accepted other Rubiaceae like *Galium mollugo* L. and *G. verum* L. The development lasts three weeks under laboratory conditions. The species shares its habitat with Ennominae species: *Charissa pfeifferi* (Wehrli, 1951), *Charissa mutilata* (Staudinger, 1879) and *Gnophos libanotica* (Wehrli, 1931).

Larva. Full-grown larva (L5) moderately slender, length 3 cm. Ground colour dorsally light green. Head beige. Epistigmatal line fine, whitish. Stigmatal line broad, ivory coloured, with a yellow tinge, indistinct. Stigmata bright yellow, bordered by a fine black margin. The whole body is covered scarcely with fine blackish setae, with small blackish patches at their bases. Ventrum uniform whitish-green (Fig. 11).

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Wehrli E (1932) Neue Geometriden-Arten und Rassen (Lepid. Het.) von der Maras-Expedition L. Osthelder u. E. Pfeiffer, München. Mitteilungen der Münchner Entomologischen Gesellschaft 22: 3–11.

Appendix

List of sequenced specimens, with identification, Sampling sites collecting data, Accession numbers, and process ID in BOLD database. Data taken from BOLD and generated by Axel Hausmann [(1)]; Norbert Pöll [(2)]; Petrányi Gergely [(3)], Dieter Stüning [(4)].

Taxon identification	Sampling site	Genbank Accession Nr.	Process ID (in BOLD database)
C. riguata [(1)]	Italy, Calabria, Prov. Cosenza, Strada per Aieta, 39.924° N, 15.793° E, 340 m, 1.IX.1991, leg. A. Hausmann, coll. ZSM	KJ637336	GWORB1728-08
C. riguata [(1)]	Slovenia, Kras-Prešnica, 45.5667 N 13.9333E, 01.V.2005, leg. M. Petru, coll. Prohaska.	KJ637333	GWOSQ288-11
C. riguata [(1)]	Greece, West-Macedonia, Vogatsikon (suedl. Kastoria), 29-May-2006, 40.4° N, 21.2° E, leg. L. Weigert, coll. ZSM, Neotype!	KJ637337	GWOSI871-10
C. riguata [(1)]	Morocco, Province Souss-Massa-Draa, Agadir env.[ironments], 10km N[orth] Agadir,30.505N 9.6628W, 15.IV.2002, leg. K. Cerny & M. Hluchy, coll. ZSM.	GU655488	GWORA2117-09
C. riguata [(1)]	Germany, Thuringia, S[üdlicher] Kyffhäuser, Ochsenburg, 08.V.2006, leg. et. coll. Dirk Stadie.	GU655489	GWORA2129-09
C. riguata [(1)]	Italy, Calabria, Prov. Cosenza, Strada per Aieta, 39,9239° N, 15,7925° E, 5000 m, 28.VIII.1997, leg. A. Hausmann, coll. ZSM	KJ637340	GWORE1485-08
C. riguata [(1)]	Croatia, Primorje-Gorski Kotar, Krk Island, Bašćanska Draga, 12.VI.2000, leg. et. coll. Dirk Stadie.	GU655487	GWORA2125-09
C. riguata [(1)]	Turkey, Dogu Anadolu, Erzincan, 20 km S. Erzincan, 39,73°N, 39,5° E, 18-Jun-1995, leg. M. Geck, coll. ZSM	KJ637338	GWOR3622-08
C. riguata [(1)]	Russia, Tuva, near Shagonar, Khairakan Mt., 565 m, 51,8953°N, 93,5375°E, 03-Jun-2010, leg. R. Yakovlev, coll. ZSM.	KJ637335	GWOSU277-11
C. dissimilata [(1)]	France.Corsica, Val d'Ese, 6km E Bastelica, 1600 m, 17.VII.2004, 41.997°N, 9.1204° E, leg. et coll. P. Skou	HQ957809	GWOSB289-10
C. uniformata [(1)]	Spain, Castilla-La Mancha, Guadalajara, 4km E Embid, 1075 m, 08.08.2007, leg. P. Skou	HQ957810	GWOSB290-10
C. uniformata [(1)]	Spain, Aragon, Torres de Albarracin, 40.4058N 1.49444W, 2.V.2003, 1250m, leg. K. Cerny, coll. ZSM	GU655485	GWORA2111-09
C. uniformata [(2)]	Spain, Aragon, Teruel, Sierra Albarracin, Moscardon, 1440 m, 22-May-2006, 40,32° N, 1,53°W, leg. R. Leimlehner, coll. N. Pöll	HM910684	GWORU564-10
C. riguata [(4)]	Georgia, Kachetia, Tusheti, David Gazeta, 4.VII.2010, 41.2724°N 45.2209°E, leg. M. Franzen, coll. ZSM	KJ637334	GWOTH404-12
C. subtilisparsata [(3)]	Iran, Mazandaran, Resteh-Ye-Elborz, Mazandaran Pass, 2988 m, 22-Jun-2005, 36,231°N, 51,438°E, leg. et coll. G. Petrany	HM393814	GWORP100-09
C. subtilisparsata [(1)]	Turkey, Dogu Anadolu, Province Malatya, Nemrut dagi northside, 38.0386N 38.7669E, 23.V.2009, 1500 m, leg. D. Stadie & H. Loebel, coll. Dirk Stadie.	GU655490	GWORA2127-09
C. subtilisparsata [(1)]	Turkey, Dogu Anadolu, Province Malatya, Nemrut dagi northside, 38.0386N 38.7669E, 23.V.2009, 1500 m, leg. D. Stadie & H. Loebel, coll. Dirk Stadie.	GU655492	GWORA2130-09
C. subtilisparsata [(1)]	Syria[Turkey], Achyr Dagh, Bertiz Jaila, 13.VII.1929, 1800 m, leg. E. Pfeiffer, Lectotype	KJ637341	GWOTY029
C. festivata [(2)]	Kyrgyzstan, Prov. Osh, Distr. Nookat, Kitschik-Alai, Abschyr-Say, 1820m, 20-Jun-2010, 40,14°N, 72,36°E, leg. et coll. N. Pöll	JN274367	GWOSM139-11
C. festivata [(2)]	Kyrgyzstan, Prov. Osh, Distr. Kara-Suu, Alai-Mountains, River Ak-Buura, Tarylga vic., 1535 m, 4-Jun-2010, 40,17°N, 72,97°E, leg. et coll. N. Pöll	JN274358	GWOSM122-11
C. festivata [(1)]	Uzbekistan, Tashkent, Parkent, reg. Surenata Mts., 900 m, 10-May-1995, 41,283°N, 69,7°E, leg. S. Murzin, coll. ZSM	KJ637342	GWOTG396-12
P. sternecki [(1)]	China, Beijing Shi, Yanqing, Dayushu, 520 m, 13-Jun-2007, 40,38°N, 115,95°E, leg. C. Wang, coll. ZSM.	KJ637339	GWORB2750-08